Why on earth would anyone want a neutrino testbeam?

John Cooper
Long Range Planning
R&D Session

- **Consider Off-Axis NuMI**
  - 50 kton detector (10 x MINOS, many $), 5 years of running,
    see about 250 ν_μ events oscillating to ν_e with θ_{13} at the Chooz limit
    - Wouldn't it be a reasonable idea to look at tagged ν_e events in smaller prototype detector(s) to learn what these events really look like?
    - Or do you always trust your Monte Carlo?
    - Do you always trust your detector design?
      - Colliders have typically tested few% prototypes of their calorimeters in testbeams of protons, pions, electrons, muons. With Neutrino detectors now at the same $ scale,…
  - Backgrounds to 2 GeV ν_e oscillation events
    - Intrinsic ν_e in the beam
    - Feed-down of higher energy ν_μ Neutral Current events (with a π^0) to fake ν_e events
    - Could we get a pure sample, i.e. **KNOWN** NC events in a testbeam?
- **Tests of Liquid Argon TPCs for far future neutrino proposals ?**
  - Remember it's far easier to get approval for testbeam time than it is to get approved to do a physics measurement

How do you get a Neutrino Test Beam ?

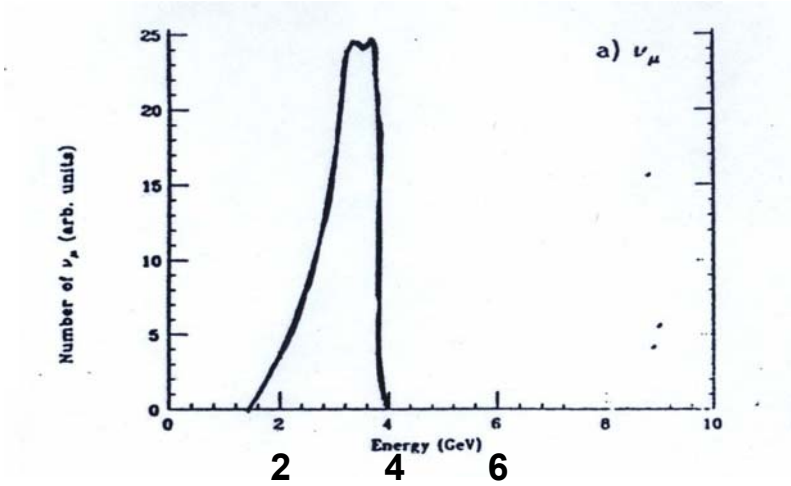
- **The Debuncher is a muon storage ring neutrino source**
  - $\gamma\tau_\pi \sim 1$ turn, so pions (➔ $\bar{\nu}_\mu$) for first 2-3 turns
  - $\gamma\tau_\mu \sim 117$ turns, so muons (➔ ν_μ and $\bar{\nu}_e$) for 150-200 turns
  - **It's always on when stacking and we are "always" stacking through 2013**
- History
  - **Proposal 860 from W.Y. Lee in 1992**
    - Not approved, sufficient statistics required positive polarity in conflict with Colliders
    - But these guys measured muon yield and calculated energy spectra
    - A. Bross et al., NIM A332, 27-31 (1993)
  - **Geer @ Snowmass 2001 & Fermilab note FN-706**
    - Measure low energy ν cross sections?
    - But the laboratory only got proposals for the NuMI Near Hall & MiniBooNE beams
    - Steve also suggested detector R&D
  - **This talk has contributions from P-860, Bross et al., S. Geer, and P. Derwent, S. Dixon, B. Fleming, H. Jostlein, A. Para, T. Lackowski**

Debuncher Neutrino Energy Spectra

for +- 10 mrad cone forward

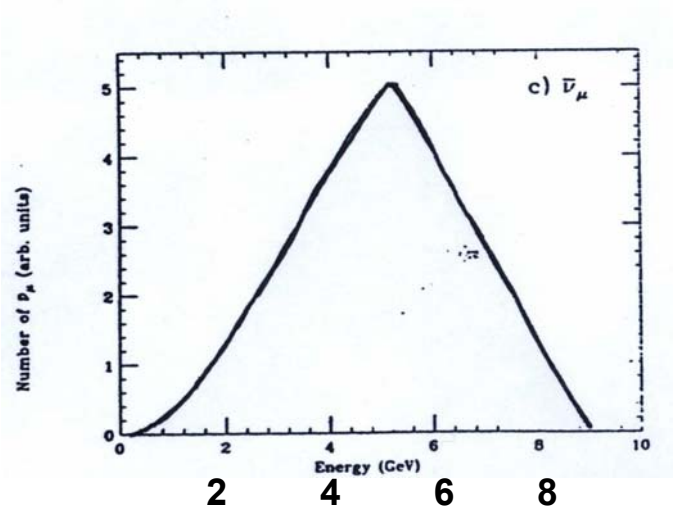
- Get 20 π's for every pbar produced

This is a two body decay, so angle & Energy are correlated at your prototype detector, giving a handle on the Neutral Currents



2 4 6

- Get 1 μ for every pbar produced



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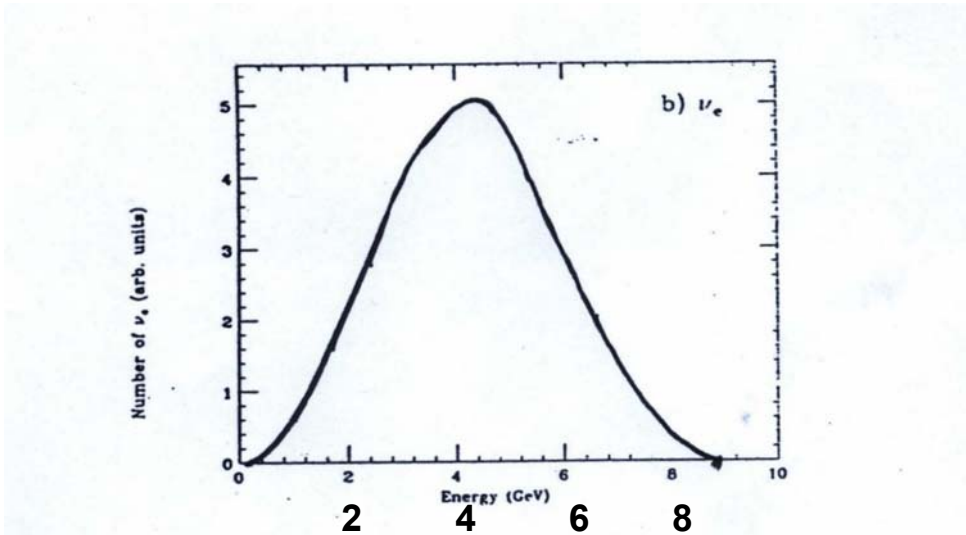
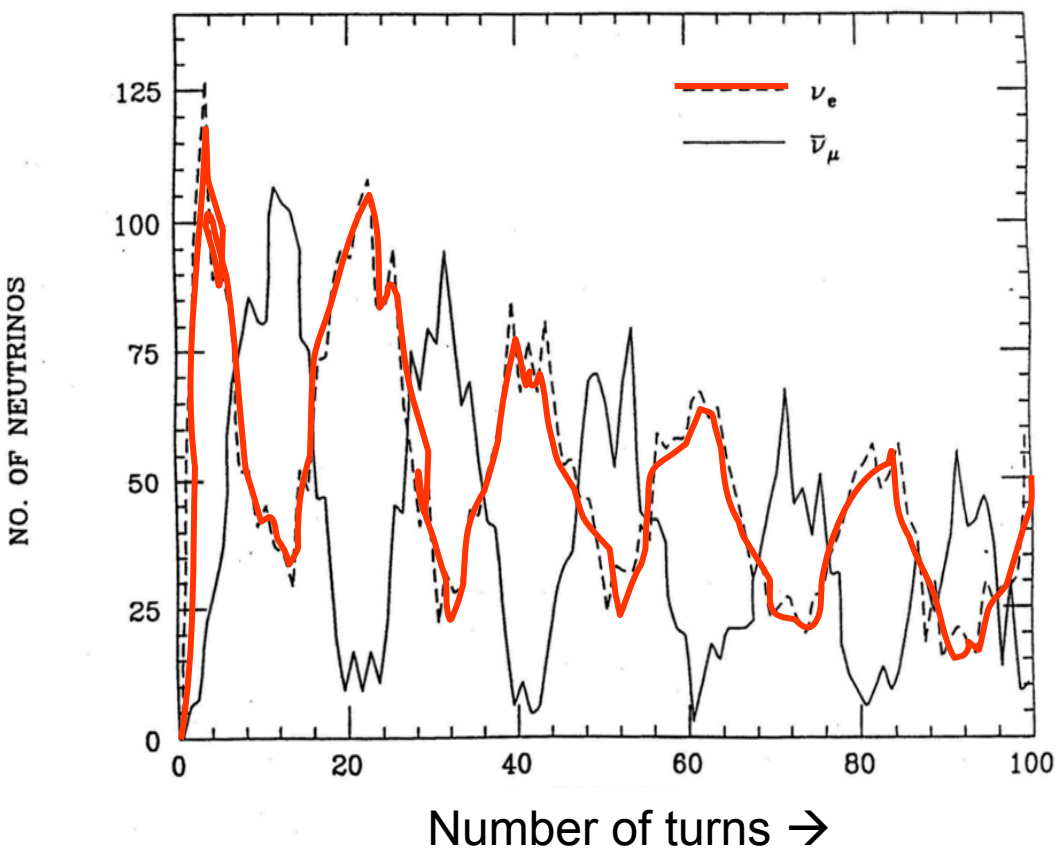


2 4 6 8

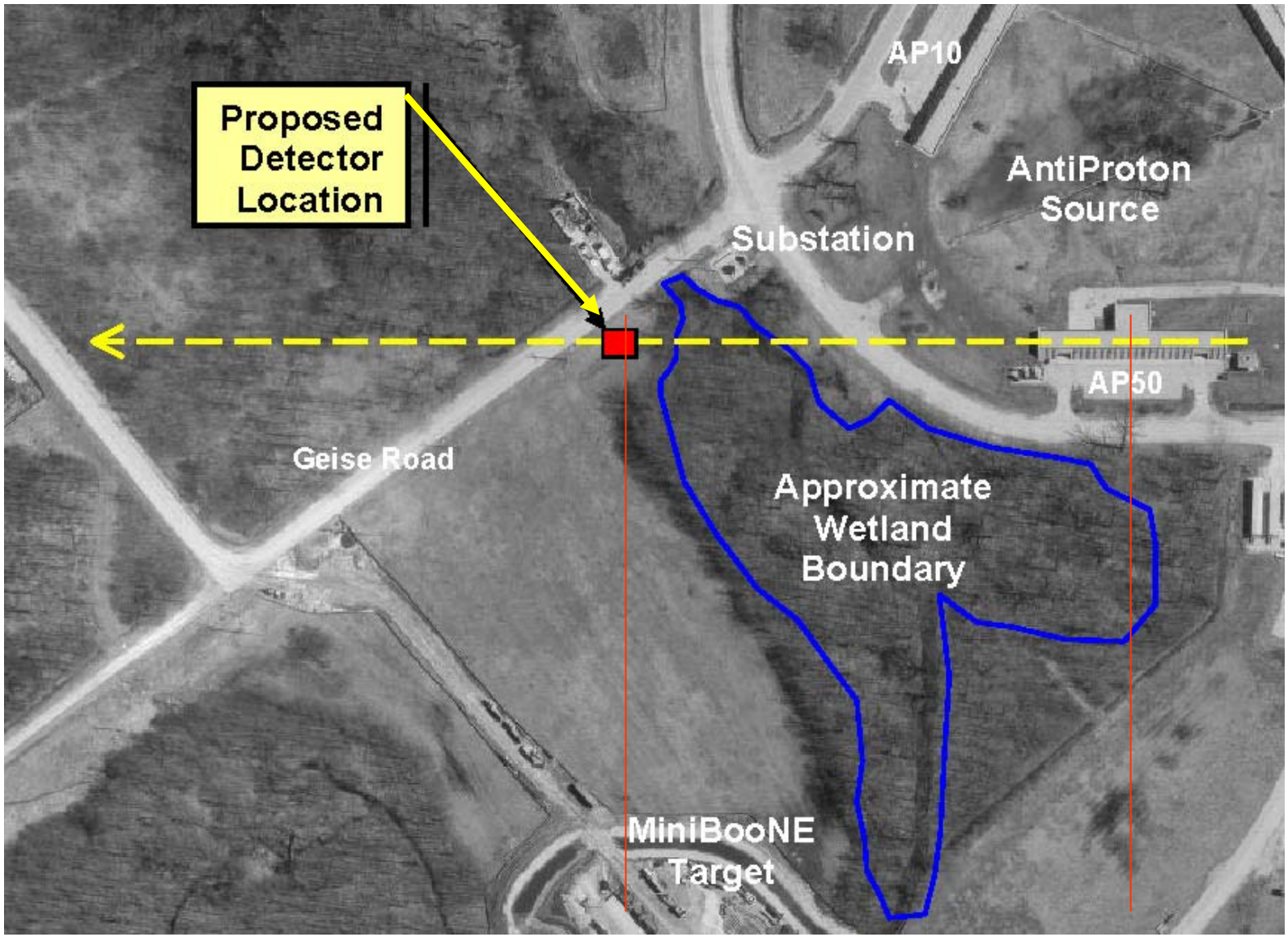
Actually get "Tagged" ν_μ *and* $\bar{\nu}_e$

- Muons captured in the Debuncher have to be within +- 2% of the momentum aperture, so only forward decays survive. V-A means that the muons are polarized
- Muon spin precesses in the magnetic field
  - Spin precession period ~ 20 turns
  - So there is a time separation of ν_μ and $\overline{\nu}_e$
- **THIS BEGINS TO LOOK LIKE A TEST BEAM !**



Also note the FIRST turn is very dominantly from π decay (no μ's yet)

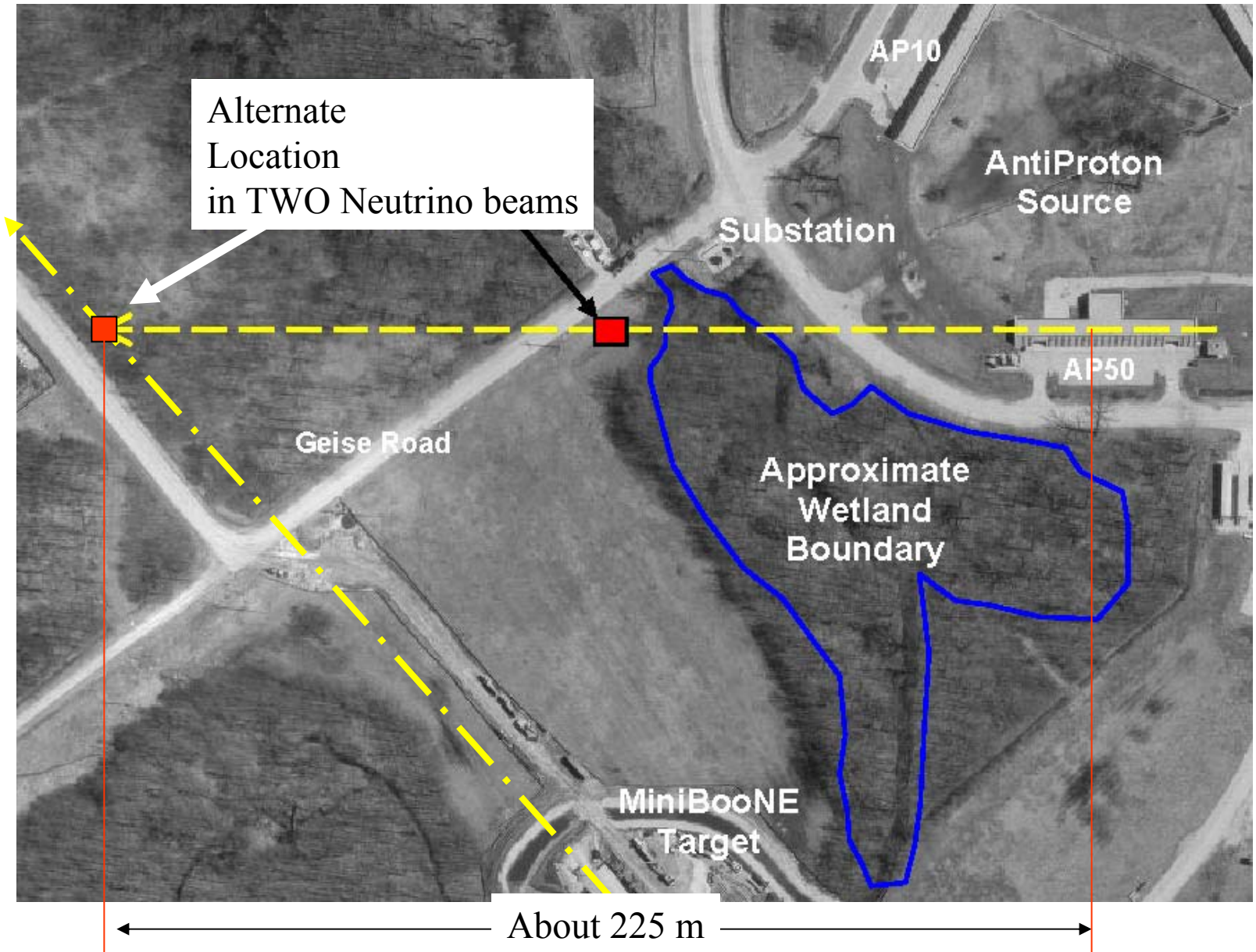
Debuncher: Neutrino Test Beam



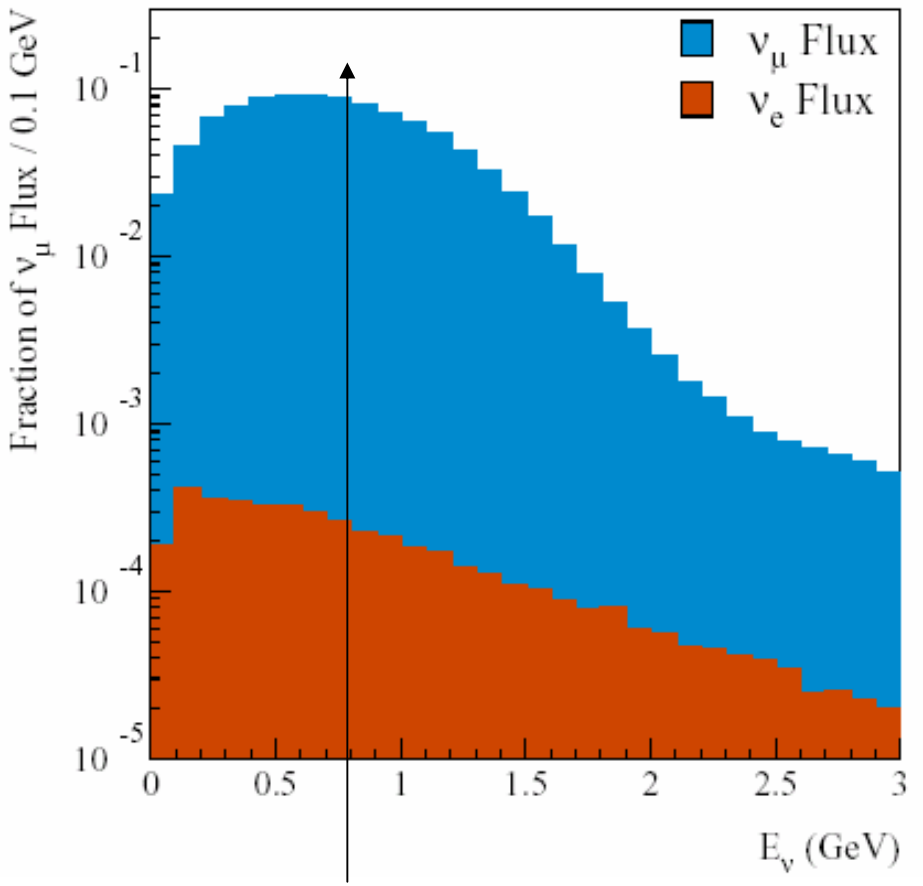
+- 10 mrad gives a spot size about 2 meters in diameter

Actually we have **two** parasitic neutrino beams

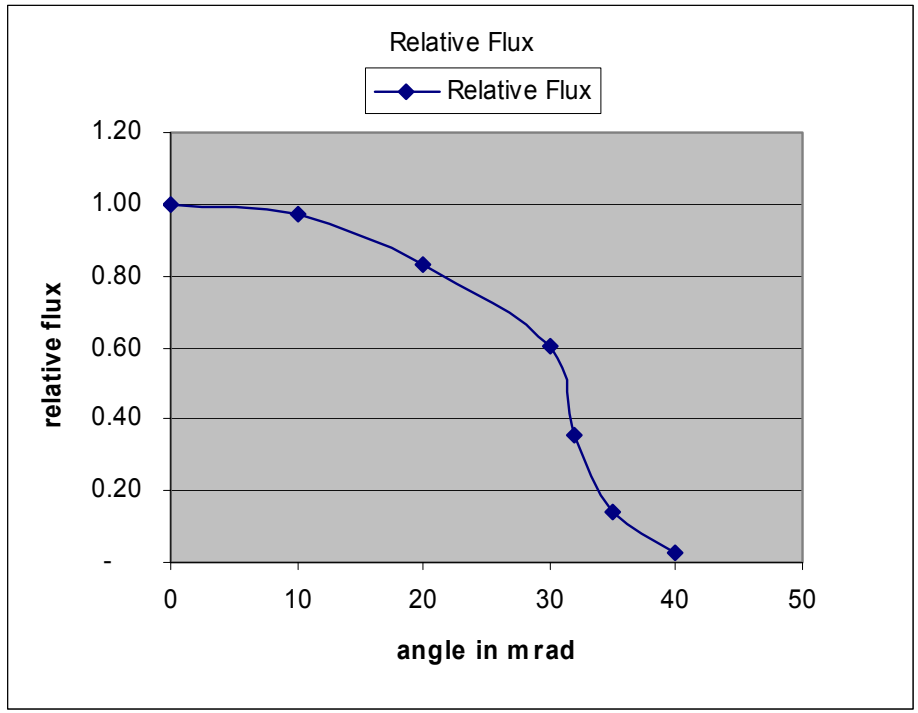
(they cross, missing by 8 feet vertically)



MiniBooNE Beam properties



Peaks at 0.8 GeV



30 mrad at about 170 meters gives a spot size of about 10 meters in diameter

Approximate Event Rates

500 Tons, one year

Debuncher			
Year	Anti ν_e	ν_μ	Anti ν_μ from pions
2003	1,800	4,000	50,000
2004	2,300	5,300	66,000
"base"	7,300	16,700	210,000
"design"	9,700	22,300	280,000

Mini-Boone	But assumes the whole beam	
	10^{20} POT	ν_μ QE
2003	1.5	75,000
2004	5.0	250,000
With NuMI	2.5	125,000

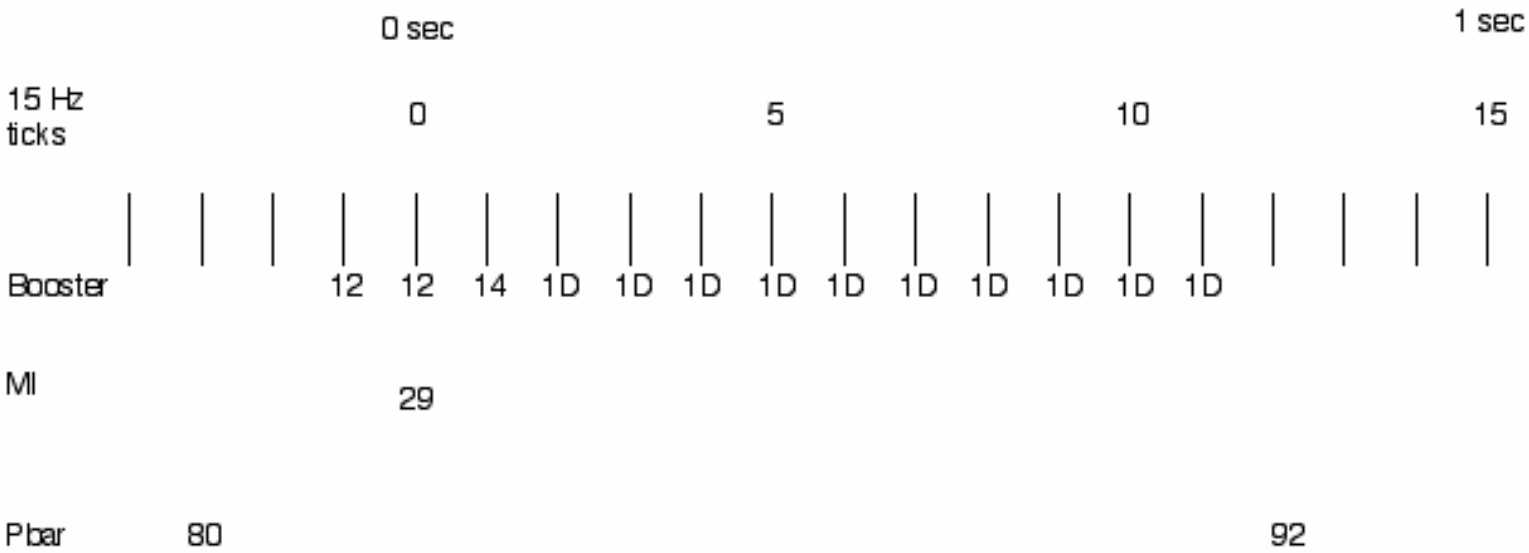
The beam is free, but we need an enclosure

Return to the thrilling days of yesteryear (cheap)
Sheet piling enclosure like PC4 (SELEX site)

Roof made of 40-ft containers (again cheapest)

Such an enclosure is about $ 10 K / linear foot, fully loaded cost

Relative Debuncher – Booster timing



Pbar $92 = $80 + 1.01 sec $92 is transfer event
MI $29 = $80 + 3 15 Hz ticks

$12 Booster Prepulse (need 2 before beam pulse)
$14 Beam to MI for pbar target
$1D Beam to MiniBoone target up to 10 in a row

Scenario as of Fall 2003

Neutrinos from debuncher and neutrinos from MiniBoone separated by 1 15 Hz tick (6.7 msec)

Scenario with Slip Stacking (implemented 2004)
additional $14 before first $1D

Neutrinos from debuncher and neutrinos from MiniBoone overlap on last 15 Hz tick